MARKED-UP SUBSTITUTE SPECIFICATION

~~DESCRIPTION~~

ELECTROSTATIC CHUCK AND ~~ITS~~ METHOD FOR MANUFACTURING ~~METHOD~~THE SAME

by Inventors

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BACKGROUND OF THE INVENTION

1. Field of the Invention

[1] The present invention relates to an electrostatic chuck, and associated manufacturing process, for use in an etching apparatus for manufacturing semiconductors~~—and its manufacturing method~~.

2. ~~Background~~ Description of the Related Art

[2] In a semiconductor manufacturing process, etching processes are repeatedly performed together with insulating film formation, diffusion processes, and photolithographic processes. There are two types of etching ~~process;~~processes: wet etching and dry etching. The dry etching process is implemented using a plasma etching apparatus as shown in ~~Fig.~~Figure 4~~,~~. ~~for~~ For example, with a semiconductor wafer W held on a chuck 12 in a processing chamber 11 of the etching apparatus, a reactive gas is introduced from an inlet 13 into the ~~above-described~~processing chamber 11 while high-frequency electric power 15 is applied between the chuck 12, which serves as a lower electrode, and an upper electrode 14 ~~so as~~ to generate a plasma in the processing chamber 11~~,~~. ~~by which chemical reaction~~Chemical reactions with ~~radical~~ radicals in the plasma and accelerated ions ~~etch~~ cause the semiconductor wafer W to be

etched.~~,~~ ~~more~~ More particularly, either the semiconductor wafer W itself or an insulating film (not shown) thereon is etched.

[3] As mentioned above, during the ~~In this~~ dry etching process, the semiconductor wafer W is held on the chuck 12~~ as described above~~. ~~Recently~~In recent etching apparatuses, ~~for~~ the chuck 12~~,~~ has been specified to be an electrostatic chuck. Electrostatic chucks have demonstrated ~~is specified due to its~~ excellent characteristics ~~proved~~ in vacuum plasma processors.

[4] The electrostatic chuck ~~attracts material to be attracted by generating~~generates electrostatic ~~attraction between the~~forces for attracting material to ~~be attracted and~~ the chuck. The electrostatic ~~attraction is made of~~forces include two types~~ of forces;~~: a Coulomb force and a Johnsen-Rahbek force.

[5] Additionally, there~~There~~ are two types of ~~the~~ electrostatic ~~chuck;~~chucks: ~~one is~~ a unipolar type and a bipolar type. With respect to Figure 5, the unipolar type of electrostatic chuck includes~~in which only~~ an anode 22 ~~is~~ formed in a dielectric material 21. Also in the unipolar type, ~~and~~ a cathode is ~~made of~~defined by the apparatus ~~and~~ such that a plasma electric potential is produced as shown in ~~Fig.~~Figure 5~~,~~. With respect to Figure 6, the ~~and the other is a~~ bipolar type of electrostatic chuck includes ~~in which~~ both an anode 32 and a cathode 33 ~~are~~ formed in a dielectric material 31~~ as shown in Fig. 6~~.

[6] ~~Referring to Fig. 7, there is shown~~Figure 7 is an illustration showing a cross-sectional view ~~illustrating an example~~ of a conventional ~~practically used~~ electrostatic chuck, in accordance with the prior art. ~~This~~ The conventional electrostatic chuck ~~comprises~~ includes an anodized aluminum film 42 ~~which is 50 to 60 μm in thickness~~disposed as a dielectric material on a surface of a disc-shaped aluminum electrode 41. The anodized aluminum film 42 has a thickness within a range extending from 50 μm to 60 μm. The semiconductor wafer W is placed on the ~~The~~ anodized aluminum film 42~~ is the material on which the semiconductor wafer W is placed~~. A cooling gas channel 43 is formed on the ~~On a~~ surface of the aluminum electrode 41 that is covered by the anodized aluminum film 42~~, is formed a cooling gas channel 43~~. The

cooling gas channel 43 extends ~~extending~~ in a circumferential direction ~~of~~ following a periphery of the aluminum electrode 41. ~~To this cooling gas channel 43, a~~A helium cooling gas is fed ~~as cooling gas~~ from gas feed orifices (not shown), penetrating the anodized aluminum film 42 and the aluminum electrode 41, to the cooling gas channel 43. The helium cooling gas ~~fed to the channel 43~~ flows into the cooling gas channel 43, fills ~~it~~the cooling gas channel 43, and then diffuses along the entire interface between the anodized aluminum film 42 and the semiconductor wafer W. The helium cooling gas diffusion occurs through fine gaps ~~therebetween~~ present along the interface between the anodized aluminum film 42 and the semiconductor wafer W. ~~generated~~ The fine gaps are defined by a rough surface of the anodized aluminum film 42~~,~~. ~~thereby~~ The helium gas diffusion serves to cool ~~cooling~~ the semiconductor wafer W. In the dry etching process performed using ~~with~~ the apparatus ~~shown in Fig.~~of Figure 4, a temperature of the semiconductor wafer W can significantly ~~affects~~ affect the resulting etching characteristics. Use of the helium cooling gas as previously described serves to cool ~~By cooling~~ the semiconductor wafer W by as much as ~~up to~~ 30 °C to 60 °C ~~with the above-described helium gas used as a heat conductive means~~, thus improving the resulting etching characteristics, especially a uniformity~~, are improved~~ characteristic.

[7] ~~In the~~The conventional electrostatic chuck as ~~set forth in the~~described above can be adversely affected through reaction product deposition. More specifically, ~~however, there is a disadvantage that~~ reaction products ~~which have been floating or otherwise dispensed~~present in the chamber 11 ~~shown in Fig. 4~~ can adhere to a surface of the anodized aluminum film 42~~,~~ after the semiconductor wafer W is removed from the chuck ~~after~~ following the etching process, thus weakening the electrostatic attraction capability of the chuck in subsequent etching processes. ~~In addition, it has a problem that the~~Additionally, reaction products adhering to the surface of the anodized aluminum film 42 ~~increases~~ can increase gaps between the anodized aluminum film 42 and the semiconductor wafer W, causing leakage of the helium cooling gas from an outer peripheral edge of the aluminum electrode 41~~,~~. ~~by which~~Consequently, leakage of the

helium cooling gas can cause the semiconductor wafer W ~~is~~ to be insufficiently cooled ~~by the helium gas and therefore~~, thus causing the etching characteristics ~~deteriorate~~to be adversely affected. Furthermore, during the etching process, the anodized aluminum film 42 ~~is~~ can be deteriorated by ~~the~~ reactive ~~gas~~ gases or ions which ~~have passed~~pass through end portions of the semiconductor wafer W ~~during etching before reaching there~~, thus ~~also~~ further weakening the electrostatic attraction capability of the chuck.

[8] ~~Accordingly~~In response to the aforementioned problems, ~~there has been devised~~ an electrostatic chuck has been developed that incorporates ~~for which~~ a ceramic layer ~~is used for~~as the dielectric material ~~as shown in Fig. 8~~. Figure 8 is an illustration showing an electrostatic chuck incorporating a ceramic dielectric layer, in accordance with the prior art. This electrostatic chuck of Figure 8 has a ceramic layer 53 bonded onto a disc-shaped metal base plate 51 by means of an adhesive layer 52. A high-melting point electrode 54 is laid in the ceramic layer 53. In this arrangement, from the viewpoint of increasing ~~the~~ electrostatic attraction, the electrode 54 is ~~located in the ceramic layer 53 relatively~~positioned near to the surface ~~thereof~~of the ceramic layer 53. ~~Specifically, on the assumption~~In one example, ~~that~~ the ceramic layer 53 is 1 mm ~~in thickness, for example,~~thick and the electrode 54 is ~~located in a position spaced~~positioned 0.3 mm away from ~~the~~ a top surface of the ceramic layer 53 and ~~spaced~~ 0.7 mm away from ~~the~~ a bottom ~~thereof~~surface of the ceramic layer 53. ~~In the same manner as for~~As with the electrostatic chuck ~~shown in Fig.~~of Figure 7, the electrostatic chuck of Figure 8 also includes ~~is formed~~ a cooling gas channel 55 formed in the top surface of the ceramic layer 53 and extending in a circumferential direction ~~of the~~following a periphery of the ceramic layer 53 ~~on the surface thereof~~. ~~This~~ The cooling gas channel 55 needs to have a certain depth ~~taking into consideration~~considering a flow of the helium cooling gas. Therefore, if the ~~above described~~cooling gas channel 55 is formed ~~in the position of~~at a location overlying the electrode 54, the close proximity of the electrode 54 ~~located relatively near~~to the top surface of the ceramic layer 53~~,~~ causes a distance between the bottom of the channel 55 and the electrode

54 to become ~~becomes~~ short~~,~~. ~~thus causing~~If the distance between the bottom of the channel 55 and the electrode 54 becomes too short, the ceramic layer 53 spanning the short distance can have an insufficient dielectric strength ~~of the ceramic layer 53~~. ~~Accordingly, in this example~~To avoid the insufficient dielectric strength issue, the electrostatic chuck of Figure 8 has the channel 55 ~~is~~ formed 1 mm to 2 mm within ~~the end~~an outer periphery of the ceramic layer 53, and the electrode 54 ~~is~~ formed ~~further~~ within an outer boundary defined by the channel 55.

[9] The ~~above-described~~ electrostatic chuck of Figure 8, however, is not without problems~~has a problem, however;~~. More specifically, since the electrode 54 ~~having~~ has a coefficient of linear thermal expansion different from that of the ceramic layer 53, and given that the electrode 54 is located ~~in~~ near a top surface of the ceramic layer 53 ~~relatively near the surface thereof~~, ~~which often causes a warpage of the ceramic layer 53 if~~ the ceramic layer 53 ~~within the electrode 54 is~~having been formed by firing is susceptible to warpage. In addition to the warpage problem, the electrostatic chuck of Figure 8 can also be adversely affected by a cooling gas leakage problem.~~,~~ ~~while a leakage of the helium~~Leakage of the cooling gas ~~fed to~~from the channel 55 ~~from the end portion of~~to the outer periphery of the ceramic layer 53 is intended to be prevented by the sealed ~~portion~~ interface between the ceramic layer 53 and the semiconductor wafer W extending between the channel 55 and the ~~end portion~~outer periphery of the ceramic layer 53~~, -~~. However, if the distance between the channel 55 and the outer periphery of the ceramic layer 53 ~~such a short distance of the sealed portion~~ (~~a~~ sealed distance) is short (e.g., ~~as~~ 1 mm to 2 mm) ~~sometimes causes~~ a gas leakage can occur through the sealed distance.

[10] Figure 9 is an illustration showing the electrostatic chuck of Figure 8 with a modification to assist in preventing gas leakage through the sealed distance, in accordance with the prior art.~~In order to prevent the gas leakage, there is also another example that~~ In the electrostatic chuck of Figure 9, the channel 55 is formed approximately 3 mm to 10 mm ~~within the end~~inside the outer periphery of the ceramic layer 53 ~~as shown in Fig. 9~~, ~~so as to~~

~~achieve~~thus providing a substantial sealed distance. ~~This example also has a problem, however;~~Placing the channel 55 further from the outer periphery of the ceramic layer 53, however, requires the electrode 54 ~~is formed further~~to be redefined to remain within the outer boundary represented by the channel 55~~ located within the end of the ceramic layer 53~~, ~~which~~ thus effectively ~~decreases~~ decreasing an area of the electrode 54~~,~~. Decreasing the area of the electrode 54 can cause~~thus causing~~ insufficient electrostatic attraction in the region between the channel 55 and the outer periphery of the ceramic layer 53~~helium gas sealed portion~~.

[11] Furthermore, there are many examples of conventional electrostatic chucks in which a semiconductor wafer ~~W~~ attracted to ~~a~~ the chuck cannot always be readily detached, or "dechucked," therefrom after a completion of etching or other processes. In some cases, it takes a considerable time for detachment of the semiconductor wafer~~ w~~.

[12] In view of the foregoing, an apparatus is needed to overcome the ~~The present invention overcomes~~ problems associated with prior art electrostatic chuck arrangements. More specifically, ~~and provides an electrostatic chuck and its manufacturing method~~the apparatus needs to prevent~~ for preventing~~ warpage of a ceramic layer and leakage of a cooling gas, ~~leakage in addition to having enhanced~~while also enhancing electrostatic attraction and requiring only a short time for detachment.

SUMMARY ~~DISCLOSURE~~ OF THE INVENTION

[13] The present invention provides an electrostatic chuck in which a disc-shaped ceramic layer having a predetermined thickness is bonded to a metal base plate by means of an adhesive layer~~,~~. ~~a~~ A planar electrode is located in the middle of the ceramic layer ~~in the middle thereof in the~~, relative to a thickness direction~~,~~. A~~a~~ cooling gas channel is formed on a surface of the ceramic layer ~~within the outer edge of the electrode and over~~at a location overlying the electrode~~, and~~ such that the electrode extends radially beyond the cooling gas channel.

[14] ~~An alternative~~Another aspect of the invention provides a method ~~of~~ for manufacturing an electrostatic chuck. ~~comprising the steps~~The method includes ~~of~~ preparing a first disc-shaped ceramic material compact having a thickness which is approximately one–half of a completed ceramic layer thickness.~~,~~ As electrode is formed ~~forming an electrode~~ on a surface of the first ceramic material compact~~,~~. The method further includes preparing a second disc-shaped ceramic material compact having a thickness which is approximately one–half of the completed ceramic layer thickness. A ~~and including a~~ cooling gas channel is included on ~~its~~ the surface of the second disc-shaped ceramic material compact within ~~the~~ an area overlying the electrode~~,~~. The method also includes placing the second ceramic material compact on the first ceramic material compact to form a laminate ~~and then~~followed by firing the entire laminate ~~so as~~ to complete the ceramic layer~~,~~. Also, ~~and bonding~~ the completed ceramic layer is bonded onto a metal base plate by means of an adhesive layer.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure~~Fig.~~ 1 is a cross-sectional view of an embodiment of an electrostatic chuck according to the present invention;

Figure~~Fig.~~ 2 is a top plan view of an electrode of the electrostatic chuck illustrated in Figure~~Fig.~~ 1;

Figure~~Fig.~~ 3 is a top plan view of a ceramic layer of the electrostatic chuck illustrated in Figure~~Fig.~~ 1;

Figure~~Fig.~~ 4 is a schematic view illustrating a dry etching apparatus, in accordance with the prior art;

Figure~~Fig.~~ 5 is a schematic view illustrating a unipolar–type electrostatic chuck, in accordance with the prior art;

Figure~~Fig.~~ 6 is a schematic view illustrating a bipolar-type electrostatic chuck, in accordance with the prior art;

Figure~~Fig.~~ 7 is a cross-sectional view illustrating a conventional first electrostatic chuck, in accordance with the prior art;

Figure~~Fig.~~ 8 is a cross-sectional view illustrating a conventional second electrostatic chuck, in accordance with the prior art; and

Figure~~Fig.~~ 9 is a cross-sectional view illustrating a conventional third electrostatic chuck, in accordance with the prior art~~;~~.

DETAILED DESCRIPTION~~ OF THE INVENTION~~

[15] The present invention provides ~~A description will be given of~~ an electrostatic chuck and a method for ~~its~~ manufacturing ~~method according to the present invention, by referring to the accompanying drawings~~the same. Several exemplary embodiments of the present invention will now be described in detail with reference to the accompanying drawings. The electrostatic chuck of the present invention ~~is~~ can be used ~~for~~ in conjunction with a dry etching apparatus. A general configuration of the dry etching apparatus ~~is shown in~~has been previously discussed with respect to ~~Fig.~~Figure 4. Accordingly, reference should be made to the discussion of Figure 4 for the ~~a~~ description of the general configuration of the dry etching apparatus~~ is omitted here,~~. ~~and only the~~The electrostatic chuck of the present invention is described in detail below.

[16] ~~Referring to Fig. 1, there is shown~~Figure 1 is an illustration showing a cross-sectional view of an electrostatic chuck, in accordance with one ~~of an~~ embodiment ~~according to~~of the present invention. As shown in ~~this diagram~~Figure 1, ~~in~~ the electrostatic chuck ~~of this embodiment,~~includes a disc-shaped ceramic layer 80 having a predetermined thickness ~~is~~ bonded onto a disc-shaped metal base plate 60 by means of an adhesive layer 70. ~~In this ceramic layer 80, a~~A planar electrode 90 ~~made of tungsten, for example,~~ is ~~laid~~ disposed within the ceramic layer 80 and is oriented to be ~~in~~ parallel to a surface of the ceramic layer 80. In one exemplary embodiment, the planar electrode 90 is made of tungsten. ~~At this point, the~~The planar electrode 90 is ~~formed in~~disposed within the ceramic layer 80 at a depth of ~~one-~~one-half of the thickness thereof~~,~~. ~~in~~ In other words, the planar electrode 90 is positioned in the middle of the ceramic layer 80 ~~in the~~relative to a thickness direction.

[17] Figure 2 is an illustration showing a ~~A~~ top plan view of ~~this~~ the planar electrode 90, ~~is shown in Fig. 2~~in accordance with one embodiment of the present invention. The planar electrode 90 ~~comprises~~ includes a first electrode 91 and a second electrode 92. Therefore, the electrostatic chuck of this embodiment is of a bipolar type~~ as shown in Fig. 6~~. The first electrode 91 ~~comprises~~ includes a disc portion 91a ~~arranged in~~defined about the center of the

ceramic layer 80~~,~~ and a linear portion 91b ~~linearly~~ extending linearly from a part of the disc portion 91a toward an outer peripheral edge of the ceramic layer 80. The first electrode 91 further ~~comprises~~ includes a ~~plurality~~ number of "C-shaped" ring portions 91c positioned at predetermined intervals so as to surround the disc portion 91a. More particularly, each of the number of "C-shaped ring portions 91c has a ~~having~~ different ~~diameters~~diameter relative to a center of the disc portion 91a and ~~extending~~ extends in a "C" ~~shapes~~ shape on both sides of the linear portion 91b ~~so as to surround the disc portion 91a~~. The second electrode 92 ~~comprises~~ includes a linear portion 92b positioned opposite to the linear portion 91b of the first electrode 91 and beyond the disc portion 91a of the first electrode 91. Also, the second electrode 92 includes a number of "C-shaped" ring portions 92c positioned at predetermined intervals and arranged complementary to the ~~plurality~~ number of ~~the~~ "C-shaped" ring portions 91c of the first electrode 91~~,~~. More particularly, each of the number ~~a plurality~~ of "C-shaped" ring portions 92c ~~at predetermined intervals having~~has a different ~~diameters~~ diameter relative to the center of the disc portion 91a and ~~extending~~ extends in a "C" ~~shapes~~ shape on both sides of the linear portion 92b~~, and, being~~ to be engaged with the ~~plurality~~ number of ~~the~~ "C-shaped" ring portions 91c of the first electrode 91. Furthermore, the electrode 91 ~~comprises~~ includes a circular ring portion 92d connected to an outer edge of the linear portion 92b ~~so as to form~~, such that the circular ring portion 92d forms the outermost peripheral portion of the planar electrode 90.

[18] ~~Returning to Fig. 1~~With respect to Figure 1, a cooling gas channel 81 is formed on a top surface of the ceramic layer 80. The cooling gas channel 81 is provided in a ring shape along the outer peripheral edge of the ceramic layer 80, as shown in a top plan view in ~~Fig.~~Figure 3. In addition, the cooling gas channel 81 is formed within the outer peripheral edge of the planar electrode 90 and over the planar electrode 90, as shown in ~~Fig.~~Figure 1. Accordingly, the planar electrode 90 passes under the bottom of the cooling gas channel 81 and extends beyond the cooling gas channel 81 ~~and up to the vicinity of~~near to the outer ~~peripheral side~~periphery of the ceramic layer 80.

[19] Gas feed orifices 82 are provided at ~~At~~ a bottom of the cooling gas channel 81~~, there are gas feed orifices 82 in a plurality of positions in a~~ in a number of locations along the circumferential direction of the cooling gas channel 81, as shown in ~~Fig.~~Figure 3. Additionally, ~~on a surface of the ceramic layer 80 in the center side,~~a number of gas feed orifices 83 are provided at a number of locations on a top surface of the ceramic layer 80. The number of gas feed orifices 83 are positioned toward a center of the ceramic layer 80 ~~arranged in a plurality of positions on a single circumference~~and at a common radius from the center of the ceramic layer 80. ~~These~~ The gas feed orifices 82 and 83 extend through the ceramic layer 80, the adhesive layer 70, and the base plate 60~~ up to the bottom thereof~~. A cooling gas such as ~~a~~ helium gas, for example, is fed from the bottom of the base plate 60. In accordance with the foregoing, the~~The~~ helium gas fed ~~to~~ through the gas feed orifices 82 and 83 ~~spouts~~ is dispensed from the bottom of the cooling gas channel 81 and from the central locations on the top surface of the ceramic layer 80~~ in the center and~~. The helium gas diffuses from both the outer peripheral portion and the central portion of the ceramic layer 80 ~~and from the center thereof on~~over the entire interface between the ceramic layer 80 and the semiconductor wafer W, as shown in ~~Fig.~~Figure 1, so as to cool the semiconductor wafer W.

[20] ~~According to the electrostatic chuck of this embodiment as described above~~In one embodiment, the electrode 90 of the electrostatic chuck includes~~comprising~~ a high-melting point metal having a coefficient of linear thermal expansion that is different from a coefficient of linear thermal expansion~~ that~~ of the ceramic layer 80. However, since the electrode 90 is ~~diposed/located~~disposed ~~in the ceramic layer 80~~ in the middle of the ceramic layer 80, relative to the ~~thereof in its~~ thickness direction of the ceramic layer 80,~~. Therefore, even if the ceramic layer 80 is formed in the electrode 90 with firing,~~ differential thermal expansion between the electrode 90 and the ceramic layer 80 will not cause the top surface of the ceramic layer 80 to warp~~is not warped so as to obtain a flat ceramic layer 80~~. Furthermore, even if the ceramic layer 80 is formed by firing, placement of the electrode 90 at the middle of the ceramic layer 80 will

allow the top surface of the ceramic layer 80 to remain flat. In addition, improvement of the flatness of the ceramic layer 80 leads to improvement of semiconductor wafer W etching characteristics (for example, uniformity) ~~of the semiconductor wafer W as well as increasing~~and an increase in the attraction of the semiconductor wafer W to the electrostatic chuck.

[21] ~~Furthermore, the~~The cooling gas channel 81 is formed ~~within the~~near an outer peripheral edge of the electrode 90 and over the electrode 90. Thus, the electrode 90 extends beyond the cooling gas channel 81~~, in other words, up to~~ and into the gas-sealed ~~portion~~region extending from the cooling gas channel 81 to the outer periphery of the ceramic layer 80. Therefore, with respect to Figure 1, the electrode 90 is positioned to apply electrostatic attraction ~~is also applied to~~over the ~~sealed portion by means of the electrode 90~~gas-sealed region as indicated by arrows~~,~~. ~~thus preventing a~~Consequently, the electrostatic attraction over the gas-sealed region prevents gas leakage from the ~~sealed portion with the electrostatic attraction~~gas-sealed region. ~~The prevention~~Prevention of ~~the~~ gas leakage leads to improved cooling ~~condition~~ of the semiconductor wafer W, thus improving the etching characteristics~~,~~ such as ~~uniformity~~ center-to-edge uniformity as measured ~~on~~ across the semiconductor wafer W.

[22] ~~Furthermore, by positioning~~Positioning of the electrode 90 in the middle ~~(in a deep position)~~ of the ceramic layer 80 ~~in its~~relative to the thickness direction of the ceramic layer 80, allows the cooling gas channel 81 ~~can~~ to be formed sufficiently deep, even ~~if it is located over~~in locations overlying the electrode 90~~,~~. Forming the cooling gas channel 81 in a sufficiently deep manner allows~~by which~~ the helium gas to smoothly ~~flows~~ flow, thus allowing~~so as to cool~~ the semiconductor wafer W to be cooled more favorably. In addition, ~~by~~ forming the cooling gas channel 81 over the electrode 90~~,~~ allows the gas-sealed region between the cooling gas channel 81 and the periphery of the ceramic layer 80 to be of sufficient distance so as to~~a long distance of the sealed portion can be secured by disposing the channel 81 within the ceramic layer 80, by~~

~~which a gas leakage can be prevented~~ more reliably prevent gas leakage. Also, forming the cooling gas channel 81 over the electrode 90 avoids a need to decrease ~~and~~ an area of the electrode 90 to accommodate~~does not need to be decreased due to~~ a position of the cooling gas channel 81. ~~Also~~Additionally, even if the electrode 90 is located ~~in~~ at a deep position in the ceramic layer 80, a sufficient electrostatic attraction can be secured ~~since~~ because electrostatic attraction is also applied to the ~~sealed portion~~gas-sealed region between the cooling gas channel 81 and the periphery of the ceramic layer 80 as described ~~in the~~ above.

[23] Furthermore, ~~by using a pattern shown in Fig. 2 for~~ the first electrode 91 and the second ~~electrodes~~electrode ~~91 and~~ 92 ~~of the electrode 90, the first and second electrodes 91 and 92 having~~each occupy an identical area ~~can be~~and are each uniformly ~~formed all~~distributed over the ceramic layer 80~~,~~. ~~by which~~Therefore, the first and second electrodes, 91 and 92, allow uniform electrostatic attraction ~~can~~ to be achieved ~~on~~ over the entire ceramic layer 80. Still further, the ratio of the area of the first electrode 91 to the area of the ceramic layer 80 can be increased, thus allowing~~by which~~ the electrostatic attraction ~~is~~ to be enhanced. Additionally, with the ~~ESC~~ electrostatic chuck of the present invention, detaching or "dechucking" ~~performance~~ of a wafer after processing is improved in comparison with ~~an ESC~~a conventional electrostatic chuck ~~made with~~having a conventional doughnut or threading pattern, ~~where~~ whereby the conventional doughnut or threading pattern causes an uneven ratio of an area of the first electrode to that of the second electrode~~,~~. ~~thus leading~~The uneven ratio of the area of the first electrode to the second electrode in the conventional electrostatic chuck can lead to a maldistribution of electric charges and ~~causing~~ cause poor dechucking performance.

~~Embodiment~~

[24] In one exemplary embodiment, the~~The~~ base plate 60, with respect to Figure 1, is preferably formed by using an aluminum 6061~~, for example~~ material. A high radio frequency (RF) power is fed to ~~this~~ the base plate 60 in order to generate a plasma in ~~a~~ the chamber 11 of ~~an~~ the etching apparatus as shown in ~~Fig.~~Figure 4. The high ~~radio frequency~~RF power to be

applied may ~~be~~ have a frequency in the range extending from~~of~~ 1 MHz to 40 MHz ~~in frequency~~ and a power in the range extending from ~~of~~ 15 W to 3000 W ~~in power~~.

[25] In one exemplary embodiment, ~~For~~ the adhesive layer 70~~,~~ is defined by a suitable, flexible, preferably organic, adhesive ~~is used~~. With the ceramic layer 80 bonded to the base plate 60 by means of the flexible organic adhesive layer 70, the ceramic layer 80 is prevented from cracking ~~caused by~~as a result of differential stress ~~due to a difference of a coefficient of linear~~induced by differential thermal expansion.

[26] In one exemplary embodiment, the~~The~~ ceramic layer 80 is formed by adding conductive additive to aluminum oxide, for example, aluminum nitride~~,~~ or magnesium oxide. In this embodiment, ~~it~~ the ceramic layer 80 is formed by using ~~a~~ aluminum oxide ~~material of~~ (Al_2O_3) as a predominant component~~,~~ and titanium oxide (TiO_2) and glass firing auxiliary material as additives. The additive TiO_2 is added to cause the ceramic layer 80 to be slightly conductive, thus allowing ~~so as to let~~ electric charges for generating electrostatic attraction rise from the electrode 90 up to the surface of the ceramic layer 80. A resistivity of the ceramic layer 80 is selected ~~so that it is~~to be within a range extending from ~~of~~ 10^{11} Ω/cm to ~~-~~10^{12} Ω/cm, and more preferably within a range ~~of~~extending from $1.0x10^{11}$ Ω/cm to 2.0~~-~~x~~-~~10^{11} Ω/cm.

[27] In one exemplary embodiment, a~~A~~ diameter of the ceramic layer 80 is slightly smaller than that of the semiconductor wafer W~~,~~. Additionally, ~~and~~ a thickness of the ceramic layer 80 is approximately 1 mm taking into consideration dielectric breakdown and an energy loss of the high-frequency power. Also in this exemplary embodiment, a surface~~Surface~~ roughness of the ceramic layer 80 is Ra=0.8 μm, and a flatness ~~thereof~~ of the ceramic layer 80 is 5 μm or lower. The outer peripheral edge on the top surface of the ceramic layer 80 is chamfered by 0.2 mm to 0.25 mm.

[28] In one exemplary embodiment, the~~The~~ cooling gas channel 81 is formed so as to extend 5 mm within the outer peripheral edge of the ceramic layer 80 and to be 1 mm wide and 0.25 mm deep. On the bottom surface of the cooling gas channel 81, eight gas feed orifices 82 are

~~formed~~ located at 45° intervals in a circumferential direction formed by the cooling gas channel 81. On the top surface and toward the center of the ceramic layer 80~~ in the center side~~, four gas feed orifices 83 are ~~formed~~ located at 90° intervals on the circumference of 0.35 mm diameter. Each gas feed orifice 82 ~~on the bottom surface of the cooling gas channel 81~~ is 0.32 mm in diameter, and each gas feed orifice 83 ~~on the surface of the ceramic layer 80 in the center side~~ is 0.35 mm in diameter. The gas feed orifices 83 on the top surface and toward the center of the ceramic layer 80 ~~in the center side~~ also serve as insertion orifices ~~of~~ for pins for lifting the semiconductor wafer W, and are therefore ~~they are~~ formed ~~so as~~ to be slightly larger than the gas feed orifices 82 on the bottom surface of the cooling gas channel 81.

[29] In one exemplary embodiment, the~~The~~ electrode 90 (consisting of the first and second electrodes 91 and 92) is made of tungsten ~~which is~~having a thickness of 10 μm to~~-~~ 20 μm~~ in thickness~~. ~~This~~ The electrode 90 is approximately 1 mm smaller in radius than the ceramic layer 80~~ in radius~~ and ~~it~~ is laid in a position spaced 0.5 mm ~~away~~ from each of the top surface and ~~0.5 mm away from the~~ bottom surface of the ceramic layer 80, wherein the ceramic layer 80 has ~~having~~ a thickness of 1 mm. In other words, the electrode 90 is positioned in the middle of the ceramic layer 80~~ in a~~, relative to the thickness direction of the ceramic layer 80.

[30] In one exemplary embodiment, the~~The~~ disc portion 91a of the first electrode 91, as shown in ~~Fig.~~Figure 2, is approximately 30 mm in diameter. The linear portion 91b of the first electrode 91 and the linear portion 92b of the second electrode 92 are each approximately 6.0 mm wide. There are seven C-shaped ring portions 91c of the first electrode 91 having consecutively increasing diameters. There are~~ and~~ seven C-shaped ring portions 92c of the second electrode 92 having consecutively increasing diameters. A single circular ring portion 92d of the second electrode 92 is provided on the outermost periphery of the electrode 90. The C-shaped ring portions 91c of the first electrode 91, the C-shaped ring portions 92c of the second electrode 92, and the circular ring portion 92d have slightly different widths~~ slightly different each other~~, ~~and their~~with an average width of the ring portions 91c, 92c, and 92d being

~~is~~ approximately 5.0 mm. ~~Respective~~ Each portion~~portions~~ of the first electrode 91 ~~are~~ is spaced 1.0 mm away from ~~respective correspondingadjacent~~adjacent portions of the second electrode 92. The total area of the first electrode 91 is 128.3 cm^2, and ~~that~~ the total area of the second electrode 92 is nearly the same size~~,~~ at 128.4 cm^2.

~~<Manufacturing method>~~

[31] In one embodiment, a manufacturing method is provided. The manufacturing method includes preparing~~Preparing~~ a first disc-shaped ceramic material compact having ~~a half~~one-half of a thickness of a ceramic layer~~80, an~~. An electrode is formed on a surface of the first ceramic material compact in a screen printing process~~ printing method~~. The method also includes preparing~~Preparing~~ a second disc-shaped ceramic material compact having ~~a half~~one-half of the thickness of the ceramic layer ~~80~~ and including a cooling gas channel on its surface at a location overlying an area to be occupied by ~~within~~ the electrode~~, the~~. The second ceramic material compact is placed on the ~~above-described~~ first ceramic material compact for contact bonding. ~~Afterward~~In following, the entire material is fired to complete the ceramic layer~~ 80~~. In ~~this process~~the presently described manufacturing method, no warpage occurs ~~since~~ due to the location of the electrode ~~is located~~ in the middle of the ceramic layer~~ 80~~, relative to the~~ in a~~ thickness direction of the ceramic layer. Subsequently, the ceramic layer ~~80~~ is bonded to an aluminum base plate ~~60~~ by means of an adhesive layer~~ 70~~.

~~<Other applications>~~

[30] While the present invention has been described ~~above by way of an example of an~~ in terms of an exemplary electrostatic chuck ~~according to the present invention applied to~~to be used in a dry etching apparatus, it should be appreciated that the electrostatic chuck of the present invention may be also be implemented within a CVD apparatus or the like, for example a target. In addition, ~~it~~ the electrostatic chuck of the present invention can be adapted for use in ~~a chuck for~~ electrostatically attracting ~~material~~ materials other than semiconductor wafers, for example, ceramic substrates.

~~Industrial Applicability~~

~~As described in detail hereinabove, according to an electrostatic chuck of~~In accordance with the disclosure above, the present invention provides an electrostatic chuck, and ~~its~~ a method for manufacturing ~~method~~the same, that prevents warpage of a ceramic layer ~~is prevented~~included therein. Furthermore, the electrostatic chuck of the present invention ~~it~~ prevents a cooling gas leakage from occurring at a~~the~~ periphery thereof and increases an electrostatic attraction.